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Management of Aphids and Thrips in Desert Head Lettuce

Project 05-09

John C. Palumbo
University of Arizona, Yuma Valley Agricultural Center

Introduction

Desert lettuce production remains highly dependant on the availability of effective and economical insecticides. The implementation of FQPA has begun and will likely result in the reduced availability of many important compounds. Consequently, development of new IPM alternatives for insect management has become especially important. Recent product registrations have resulted in important IPM tools for desert lettuce growers that provide excellent control of worms, *leafminers*, and whiteflies. There are several additional chemistries currently under development that will be available for insect management in the next few years. Research to evaluate and develop these products for desert lettuce IPM programs has been supported through funding provided by AILRC and the Agrochemical industry over the past several years.

However, thrips and aphids still remain key pests of spring lettuce in the desert and represent the most important insect problems currently facing the industry. Several new promising insecticides that are in early stages of development are being evaluated for their control. However, the presence of a new aphid species, the currant-lettuce aphid, *Nasonovia ribisnigri*, and the foxglove aphid, *Aulacorthum solani*, presents some new challenges. We are still uncertain how this new species will behave under desert growing conditions. Research to learn more about its damage potential and control in the desert needs to continue. Furthermore, western flower thrips remain a very difficult pest to control and no compounds are being developed specifically for its management. Many of the compounds currently used for controlling thrips (Lannate, Orthene, Dimethoate) are directly threatened by FQPA. The intention of this proposal is to continue evaluation of new chemistries and management approaches under local growing conditions and generate new information that will allow Arizona growers to cost-effectively manage these pests.

Aphids are one of the most important insect problems in head lettuce grown in Arizona. A new aphid species, the foxglove aphid, *Aulacorthum solani*, was found infesting commercial lettuce fields in the Yuma area for the first time this past growing season. It has been known to occur in California since at least 1940, and along with the lettuce aphid, *Nosanovia ribis-nigri*, has caused problems for lettuce growers in Salinas area for the past several years. Although, the lettuce aphid is the more important of the two in Salinas, studies last spring suggest that foxglove aphid may be a more important pest in the desert. Foxglove aphids are thought to occur throughout the U.S and Canada, but its effect is generally greatest in the eastern regions of the continent. It is also found worldwide, but is probably of European origin.

The foxglove aphid appears to be similar to the lettuce aphid in that the alates (winged forms) are difficult to differentiate, both aphids have short life cycles that allow populations to build up rapidly, and both tend to prefer to colonize the youngest tissue near the terminal growing point of the plant. Apterae (wingless forms) foxglove aphid are also often confused with the green peach aphid, *Myzus persicae*. Both aphids are usually yellow-green to all green but the green peach aphid may also be somewhat pink or red, as is the lettuce aphid. The foxglove aphid is slightly larger (maximum length is 3.0 mm) than the green peach aphid (max. length is 2.3 mm). One way to distinguish these two aphids is by the dark joints found on legs and antennae of the foxglove aphid, and the dark tips of the cornicles. The green peach aphid also has pale-colored legs and antennae but without dark joints. Foxglove aphids are also unique in that they have a bright green or dark colored spot at the base of each cornicle. Alates have a pattern of transverse dark bars on the dorsal abdomen.

The foxglove aphid was not previously thought to occur in Arizona. It is principally considered a serious pest of potatoes and is also found on ornamental and greenhouse plants. It is considered an occasional pest of lettuce and leafy vegetables grown in Canada. Unlike the lettuce aphid which was first found in Yuma five years ago, the foxglove aphid is known to colonize a much broader range of plant hosts, including a wide variety of weeds, ornamentals and crops. This large availability of hosts and apparent adaptation to our winter and spring growing conditions suggests that foxglove aphids might present growers with some new challenges.

There is much uncertainty surrounding this new species, and its ability to thrive within our desert growing conditions. We are not sure how or when the foxglove aphid moved into the Yuma area, but it seems likely that it may have arrived via transplants or harvest equipment, much like we suspect with the lettuce aphid. Because this species is polyphagus and utilizes a number of known host plants grown in the desert, we are concerned that foxglove aphids may become an established pest on our winter/spring crops. In terms of management, control with foliar aphicides appears to be more difficult because the aphids preference for the protected terminal growth. We have had the opportunity to conduct a considerable amount of field research over the past two growing seasons to learn more about this pest. Because of the importance of the foxglove as a contaminant of lettuce and other leafy vegetables, we designed several studies to its examine its population growth, distribution, and damage potential.

Impact of Planting Date on Aphid Infestations and Contamination in Head Lettuce

Materials and Methods

To examine the population dynamics and damage potential of aphid species across five planting dates, experimental field plots were established in head lettuce at the University of Arizona, Yuma Agricultural Center. Beginning in mid-October 1999, 0.2 acre plots of head lettuce were planted on 2-3 week intervals. Table 1 provides the planting date and lettuce variety for each planting in each year of the study . On each planting date (wet date) lettuce was direct seeded into double row beds on 42 inch centers. Each planting was subdivided into 4 plots consisted of 4 beds, 150 feet long. Plots were arranged in a randomized complete block design with four replications. No insecticide applications were made during the study. Aphid populations were assessed by estimating the number of aphids/plant by taking whole plant destructive samples. On each sampling date, 10 plants were randomly selected from each plot and placed individually into large 4-gal tubs. Each plant was sampled by visually examining all plant foliage and counting the number of alate and apterous aphids present. At harvest, infestation levels of apterous aphids were estimated by randomly selecting 10 plants within each replicate, visually counting the number of aphids on frame/wrapper leaves and heads, and separately recording aphid numbers for each location. Weather data observed from the AZMET station at the Yuma Ag Center was used to examine the influence of temperature and rainfall on foxglove abundance and population growth.

Results and Discussion

Seasonal aphid abundance and timing of infestation for each planting date for the 5 growing season is shown in figures 1-4. Population growth and head contamination varied among the species and was influenced in part by weather occurring during each planting (Table 1). Green peach aphid has traditionally been the most abundant and economically important aphid species infesting desert lettuce. However, GPA occurred only sporadically during the first four years of this study (Figure 1). Last season though, GPA reached very high population levels in the October plantings, and crashed with the high temperatures that occurred in March. Economic head contamination by GPA was recorded only in the 30 Oct planting date (Table 1). Based on a summary of the past 5 years, the lettuce crops at most risk from GPA were during the late-October and early-November planting windows (Table 2).

PA and AL aphids have varied in abundance among planting dates over the past 5 years (Fig 2). Similarly they varied in abundance from year to year, peaking in the spring of 2003. Head contamination by PA and AL was only observed in 2001 and 2003 (Table 1). Last season, PA and AL infestations were extremely light showing up in the late Oct planting at sub-threshold densities. Similarly, head contamination by these species was not economic in 2004. Overall these species appear to be most abundant in the late-November and December plantings (Table 3). LA was first observed in the Yuma area and in our studies in 1999. Since then they have been sporadically abundant during each year (Figure 3). However, LA infestations were quite damaging to heads in the spring 2003, and almost exclusively in the December plantings (Table 1). Because this aphid species tends to prefer higher temperatures, the lettuce plantings that are seeded in Decemeber and harvest in March appear to be at most risk from LA. (Table 4).

FG aphids first appeared in our lettuce trials 3 years ago and have continued to increase their abundance in each successive season (Figure 4). Their numbers were quite high during the 2003 season and appeared to be increasing to even higher number in 2004 but declined in the later plantings due to the high temperatures we experienced in March. Based on the limited 3 years of data, this species has the potential to cause economic contamination of heads in November and December plantings (Table 1) and consequently, appears to have the potential to be at rsik to lettuce crops planted during November and December (Table 5).

In conclusion, the data generated from this study clearly demonstrates that a multiple complex of economic aphid species occurs in desert lettuce. This complex is capable of causing economic damage through contamination to lettuce heads in direct seeded plantings from late October through December. Because aphid abundance and timing of infestations varies from species to species, proper identification will be important for management. This is due in part because aphid susceptibility to different classes of insecticides varies between species. In addition, it is further recommended that growers should begin applying soil systemic insecticides such as Admire (imidacloprid) for aphid control beginning in late October and continuing until planting is over in December.

Figure 1. Green peach aphid populations in head lettuce in 5 plantings each year from 1999-2005.

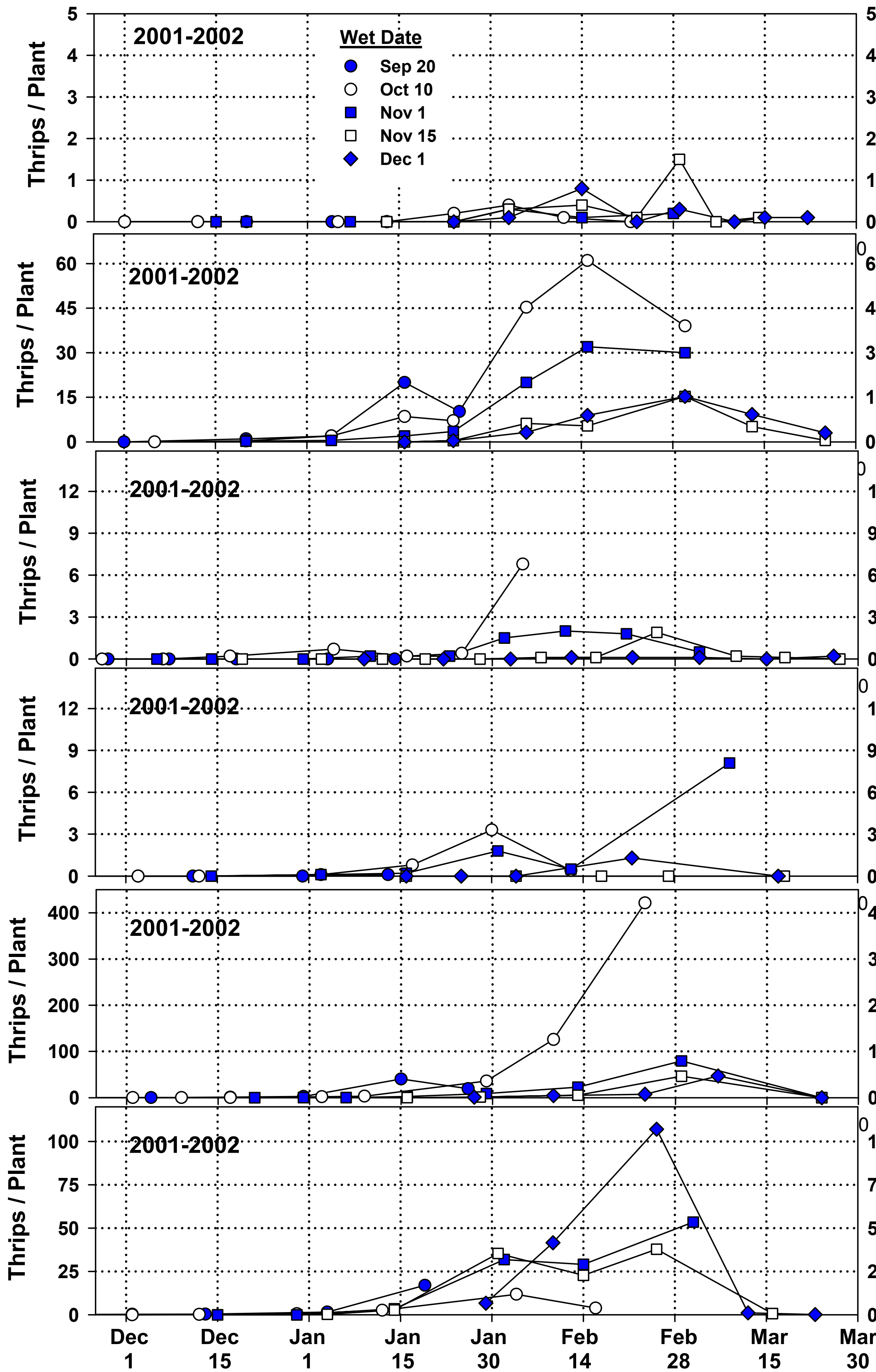

Figure 2. Foxglove aphid populations in head lettuce in 5 plantings each year from 1999-2005.

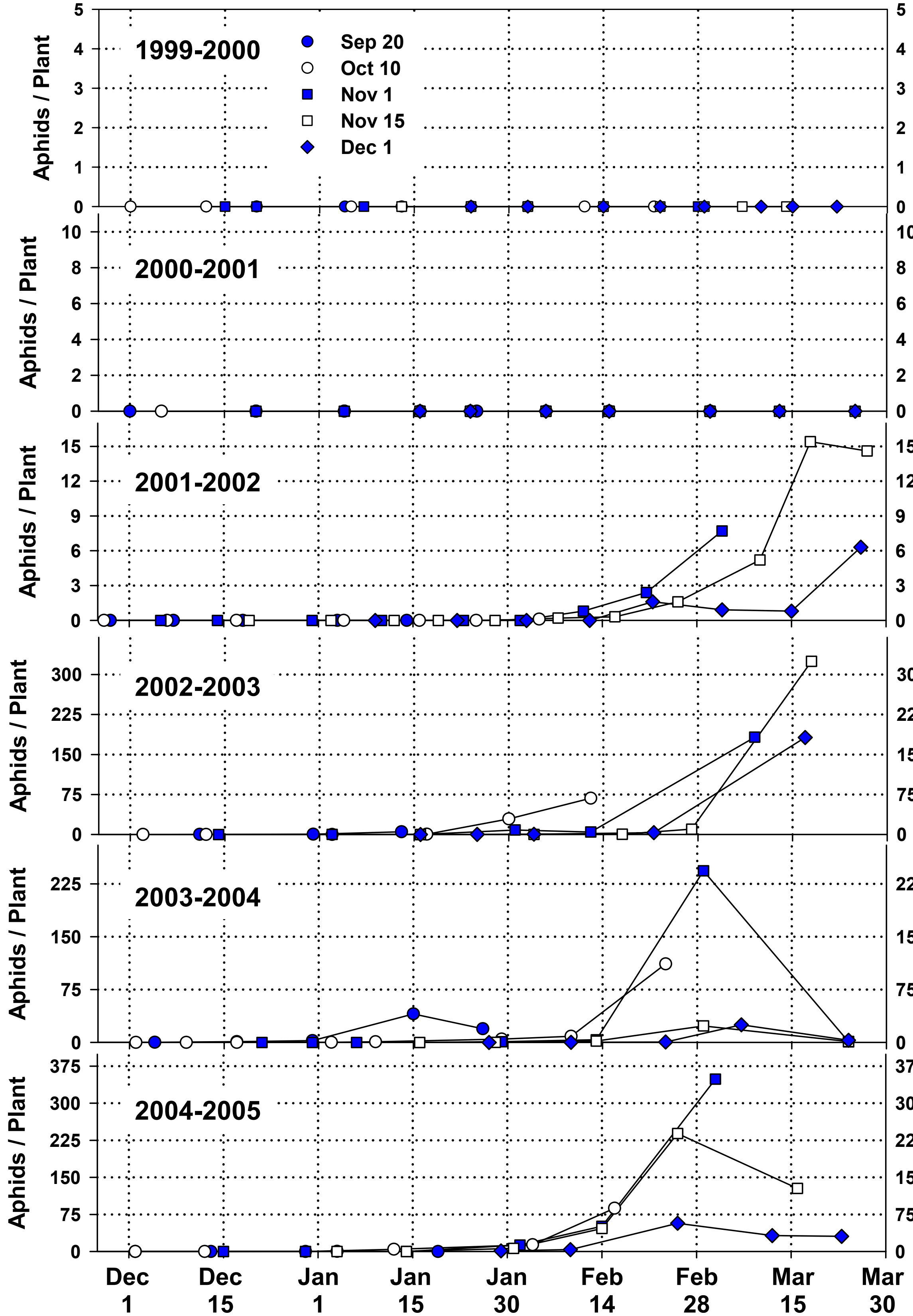

Table 1. Seasonal Avg. Green peach aphids / plant

Season	Wet date				
	11-Oct	2-Nov	15-Nov	3-Dec	15-Dec
1999-2000	0.0	0.1	0.1	0.3	0.2
2000-2001	5.5	20.4	12.6	4.7	5.7
2001-2002	0.0	1.0	0.7	0.2	0.1
2002-2003	0.0	0.8	1.8	0.0	0.3
2003-2004	10.6	**73.6**	14.2	10.6	12.0
2004-2005	3.2	3.2	19.7	16.6	**31.3**
6 Yr Avg	3.5	**19.7**	9.1	6.9	10.9

Table 2. Seasonal Avg. Potato aphids[a] / plant

Season	Wet date				
	11-Oct	2-Nov	15-Nov	3-Dec	15-Dec
1999-2000	0.0	0.1	2.5	3.5	1.0
2000-2001	1.3	6.7	4.6	1.6	2.7
2001-2002	0.2	0.4	1.5	0.8	5.6
2002-2003	2.3	1.4	72.2	**94.2**	60.1
2003-2004	0.0	0.1	0.0	0.0	0.0
2004-2005	0.0	1.5	7.4	5.5	6.5
6 Yr Avg	0.6	2.0	**14.7**	**17.6**	**12.7**

[a] includes *Acrythosiphum lactucae* populations

Table 3. Seasonal Avg. Foxglove aphids[b] / plant

Season	Wet date				
	11-Oct	2-Nov	15-Nov	3-Dec	15-Dec
2001-2002	0.0	0.1	1.2	14.6	1.5
2002-2003	1.1	16.3	32.6	**67.1**	37.2
2003-2004	1.4	25.1	**49.8**	5.6	5.7
2004-2005	0.0	17.6	**68.7**	**69.8**	24.9
6 Yr Avg	0.6	14.8	**38.1**	**39.3**	17.3

[b] foxglove aphids not reported prior to the 2001-2002 season

Table 4. Seasonal Avg. Lettuce aphids / plant

Season	Wet date				
	11-Oct	2-Nov	15-Nov	3-Dec	15-Dec
1999-2000	0.0	0.1	1.6	1.2	4.4
2000-2001	0.0	1.0	1.2	3.1	9.1
2001-2002	0.0	0.0	0.9	0.2	0.7
2002-2003	0.0	0.1	5.1	32.8	40.2
2003-2004	0.0	0.0	0.0	0.1	0.5
2004-2005	0.0	0.0	3.1	5.0	3.2
6 Yr Avg	0.0	0.2	2.0	**7.1**	**9.7**

Table 5. Aphid Contamination levels in lettuce heads and frame leaves at harvest in 5 plantings each growing, YAC 1999-2005

				Temperature (°F)			Rain	Mean Apterous Aphids / Plant at Harvest					
								Green Aphid Complex [a]		Lettuce Aphid		Foxglove Aphid	
Season	Wet date	Harvest	Variety	Max	Min	Avg	(inch.)	Head	Frame	Head	Frame	Head	Frame
1999-2000	11-Oct	24-Jan	*Grizzley*	*81*	48	64	0	0	0	0	0	-	-
	1-Nov	20-Feb	*Wolverine*	*75*	45	58	0.1	0	0	0	0	-	-
	15-Nov	1-Mar	*Del Rio*	*75*	45	59	0.1	1.3	0.6	12.3	0	-	-
	1-Dec	23-Mar	*Jackel*	*73*	44	60	0.3	0.3	0.3	8.2	0.5	-	-
	15-Dec	23-Mar	*Diamond*	*74*	45	60	0.3	0.2	0.1	42.9	0.6	-	-
2000-2001	11-Oct	25-Jan	*Grizzley*	*74*	50	61	1.2	2	14.4	0	0	-	-
	1-Nov	2-Mar	*Wolverine*	*70*	45	57	1.16	15.2	38.5	5.1	0	-	-
	15-Nov	3-Mar	*Del Rio*	*70*	44	56	1.12	8.5	42.6	6.5	0.9	-	-
	1-Dec	26-Mar	*Jackel*	*72*	46	58	2.9	2.6	12.9	9.6	0.4	-	-
	15-Dec	26-Mar	*Diamond*	*73*	47	59	2.9	0.3	3.0	8.2	0.6	-	-
2001-2002	10-Oct	14-Jan	*Wolverine*	*78*	49	63	0.1	0	0	0	0	0	0
	28-Oct	4-Feb	*Grizzley*	*72*	44	58	0	0	2.3	0	0	0.3	0
	15-Nov	5-Mar	*Wolverine*	*74*	44	58	0	0.5	7.1	0	0	0	0.1
	3-Dec	22-Mar	*Diamond*	*72*	41	57	0	3.6	7.9	1.1	0.1	1.4	6.3
	13-Dec	6-Apr	*Diamond*	*73*	42	57	0	1.0	1.5	6.3	0.4	11.7	2.9
2002-2003	10-Oct	14-Jan	*Winterhaven*	*77*	47	59	0.03	0.4	3.5	0	0	0.5	3.4
	29-Oct	12-Feb	*Winterhaven*	*74*	45	59	1.27	1.1	6.9	0	0	2.4	48.1
	14-Nov	9-Mar	*Bubba*	*73*	45	59	1.27	96.6	244.6	44.7	16.4	33.9	150.9
	3-Dec	18-Mar	*Diamond*	*73*	44	58	1.23	105.5	345.6	145.7	21.4	125.9	201.3
	12-Dec	18-Mar	*Diamond*	*74*	45	59	1.23	126.2	170.9	182.2	18.9	81.8	101.0
2003-2004	15-Oct	26-Jan	*Honcho*	*75*	47	61	0.46	3.6	12.7	0	0	0.8	2.9
	30-Oct	24-Feb	*Bubba*	*70*	46	56	0.46	149.7	272.8	0	0	21	90.4
	19-Nov	16-Mar	*CoachSupreme*	*70*	43	56	0.36	0	0	0	0	0.7	0
	3-Dec	25-Mar	*Diamond*	*73*	44	58	0.36	0	0	0	0	1.3	0
	12-Dec	25-Mar	*Diamond*	*74*	45	59	0.36	0	0	0	0	2.2	0.4
2004-2005	14-Oct	19-Jan	*Grizzley*	*70*	45	57	2.23	4.9	12.0	0	0	0	0
	3-Nov	16-Feb	*Bubba*	*69*	45	57	2.26	3.8	3.9	0	0	59.9	27.2
	17-Nov	4-Mar	*Bubba*	*68*	45	57	2.68	24.9	71.1	16.5	0.8	235.5	113.1
	1-Dec	15-Mar	*DesertSpring*	*70*	46	58	2.58	3.9	8.3	15.9	0.4	91.3	36.2
	15-Dec	24-Mar	*Diamond*	*70*	46	59	1.98	5.3	0.3	10.3	0.1	27.4	3.2

[a] Green aphid complex consisting of *Acyrthosiphon lactucae* , potato aphid and green peach aphid

Insecticide Efficacy Against Aphids on Head Lettuce

Study 1.

Materials and Methods

The objective of this study was to evaluate the efficacy of two new active ingredients, flonicamid and acetamiprid, as foliar sprays for control of aphids on spring head lettuce under desert growing conditions. Lettuce was direct seeded on 17 Nov at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, furrow irrigated thereafter. Plots were two beds wide by 45 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a randomized complete block design. Formulations and rates for each compound are provided in the tables. Foliar applications were made with a CO_2 operated boom sprayer operated at 60 psi and 26.5 GPA. A directed spray (nozzles directed toward the plants) was delivered through 3 TX-12 ConeJet per bed. A total of 3 spray applications were applied on 18 Jan, 28 Jan, and 9 Feb. The first spray was initiated at early aphid colonization -0.25 GPA / plant, 0.3 FGA / plant. An adjuvant, DyneAmic (Helena Chemical Co.), was applied at 0.125%v/v to all spray applications. Aphid populations were assessed by estimating the number of aphids /plant in whole plant, destructive samples at 10-14 d intervals following treatment (DAT). The final sample coincided with crop harvest. On each sample date, 8 plants were randomly selected from each plot and placed individually into large 3-gal plastic tubs. Each plant was sampled by visually examining all plant foliage and counting the number of apterous aphids present. On the final sample (Feb 23), infestation levels of apterous aphids were estimated by randomly selecting 10 plants within each replicate, visually counting all aphids found within heads and wrapper leaves. Because of heterogeneity of mean variances, insect data were summed for each sample date and transformed [$\log_{(y+1)}$] prior to a 1-way analysis of variance. The mean values were then subjected to a protected LSD $_{(p<0.05)}$ F test to distinguish treatment mean differences. The untransformed mean values for each life stage are presented in the tables.

Results and Discussion

Aphid pressure was light to moderate in this trial and peaked at harvest during late February. FGA was the dominant aphid species, particularly at harvest. GPA was present only in light numbers and was not a factor at harvest. All the spray treatments significantly reduced numbers of FGA following the 1st and 2nd applications (Table 1) . At harvest (14 DAT#3), all treatments except Assail applied alone, had signifcntly fewer aphids per head than the untreated control. However, the combination of Capture with Assail did provide significant aphid reduction relative to the untreated control. The lack of significant activity of Assail and Provado on FGA was not unusual as we have previously observed inconsistent efficacy of the neonicotinoids on FGA, regardless of application methods. In contrast, flonicamid provided excellent activity against FGA, and aphid control was not enhanced by the addition of the pyrethroid. All compounds had significant activity against GPA following the 2nd spray. However, GPA numbers were very light at harvest and did not differ among treatments. The new compound BYI 8336 provided exceptional aphid control, particularly considering that it was only applied once at 35 before harvest.

		Foxglove aphid		
		Mean Aphids / Plant		
Treatment	**Rate/ac**	**Jan 28 (10 DAT#1)**	**Feb 8 (11 DAT#2)**	**Feb 23 (14 DAT#3)**
Provado 1.6F	3.75 oz	0.6	0.6 b	4.6 b
Provado 70 WG	1.07 oz	0.8	0.9 b	4.5 b
Assail 30 WG	4 oz	3.9	2.1 b	9.6 b
Flonicamid 50 WG	2.33 oz	0.0	0.1 b	1.4 b
BYI 8336	8 oz	0.1	0.4 b	3.3 b
Capture+Assail	6 oz + 4 oz	0.3	0.5 b	6.9 b
Capture+Flonicamid	6 oz + 2.3 oz	0.0	0.0 b	0.7 b
Untreated	--	1.1	11.2 a	53.0 a
	F value	*1.82*	*3.8*	*3.81*
	Pr > F	*0.13*	*0.007*	*0.008*

[a] BYI was only applied on the 1st application (Jan 18)

		Harvest		
		Foxglove aphid		
Treatment	**Rate/ac**	**Head**	**Wrappers**	**Total**
Provado 1.6F	3.75 oz	3.7 bcd	0.9 b	4.6 b
Provado 70 WG	1.07 oz	4.2 bcd	0.3 b	4.5 b
Assail 30 WG	4 oz	9.5 ab	0.2 b	9.6 b
Flonicamid 50 WG	2.33 oz	0.9 cd	0.5 b	1.4 b
BYI 8336	8 oz	2.8 bcd	0.5 b	3.3 b
Capture+Assail	6 oz + 4 oz	4.6 bcd	2.2 b	6.9 b
Capture+Flonicamid	6 oz + 2.3 oz	0.6 d	0.1 b	0.7 b
Untreated		38.9 a	14.1 a	53.0 a
	F value	*4.13*	*2.92*	*3.81*
	Pr > F	*0.005*	*0.02*	*0.008*

[a] BYI was only applied on the 1st application (Jan 18)

Green Peach Aphid

Treatment	Rate/ac	Mean Aphids / Plant Jan 28 (10 DAT#1)	Feb 8 (11 DAT#2)	Feb 23 (14 DAT#3)
Provado 1.6F	3.75 oz	0.1	0.1 bc	0.2
Provado 70 WG	1.07 oz	0.0	0.2 bc	0.0
Assail 30 WG	4 oz	0.0	0.6 b	0.1
Flonicamid 50 WG	2.33 oz	0.2	0.0 c	0.1
BYI 8336	8 oz	0.3	0.4 b	0.2
Capture+Assail	6 oz + 4 oz	0.0	0.0 c	2.1
Capture+Flonicamid	6 oz + 2.3 oz	0.2	0.0 c	0.0
Untreated	--	0.4	5.1 a	2.8
	F value	*2.07*	*11.46*	*1.72*
	Pr > F	*0.09*	*0.0001*	*0.16*

[a] BYI was only applied on the 1st application (Jan 18)

Harvest

Treatment	Rate/ac	Green Peach Aphid Head	Wrappers	Total
Provado 1.6	3.75 oz	0.1	0.1	0.2
Provado 70 WG	1.07 oz	0.0	0.0	0.0
Assail 30 WG	4 oz	0.0	0.1	0.1
Flonicamid 50 WG	2.33 oz	0.1	0.1	0.1
BYI 8336	8 oz	0.1	0.1	0.2
Capture+Assail	6 oz + 4 oz	1.4	0.7	2.1
Capture+Flonicamid	6 oz + 2.3 oz	0.0	0.0	0.0
Untreated		0.8	2.1	2.8
	F value	*1.4*	*1.63*	*1.72*
	Pr > F	*0.25*	*0.18*	*0.16*

[a] BYI was only applied on the 1st application (Jan 18)

Study 2.

Materials and Methods

The objective of this study was to evaluate the efficacy of several new selective insecticides, compared to older conventional insecticides, against aphids on spring head lettuce under desert growing conditions. Lettuce was direct seeded on 18 Nov at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, furrow irrigated thereafter. Plots were four beds wide by 45 ft long and bordered by two untreated beds. Each treatment was replicated four times and arranged in a randomized complete block design. Foliar applications were made with a CO_2 operated boom sprayer operated at 60 psi and 27 GPA. A directed spray (nozzles directed toward the plants) was delivered through 3 TX-12 ConeJet per bed. A total of 4 spray applications were applied on 13 Jan, 27 Jan, 19 Feb, and 4 Mar. The first spray was initiated at early aphid colonization -8.0 GPA / plant, 0.2 FGA / plant. An adjuvant, DyneAmic (Helena Chemical Co.), was applied at 0.125%v/v to all spray applications. On the last two applications Capture 2E at 5.0 oz was combined with the dimethoate and endosulfan treatments. Aphid populations were assessed by estimating the number of aphids /plant in whole plant, destructive samples. On each sample date, 8 plants were randomly selected from each plot and placed individually into large 3-gal plastic tubs. Each plant was sampled by visually examining all plant foliage and counting the number of apterous aphids present. At harvest infestation levels of apterous aphids were estimated by randomly selecting 10 plants within each replicate, visually counting all aphids on frame/wrapper leaves and heads separately. Data were analyzed as a 1-way ANOVA using a protected LSD *F* test to distinguish treatment mean differences

Results and Discussion

Aphid pressure was moderate in this trial and peaked at harvest during mid-March. GPA was the dominant aphid species, particularly early, but FGA populations emerged at comparable levels at harvest. Contrary to local IPM recommendations, fFoliar sprays were initiated at relatively high aphid densities (> 8 aphids / plant). However, both Assail and Flonicamid provided excellent control following each application and maintained populations of both aphid species to low levels at harvest (Table 1 and Table 2). Fulfill provided good control of FG, but did not provide comparable protection of head contamination from GPA at harvest (Table 3). Stretching the 2nd application for 21 days allowed the GPA population to build up to higher numbers in the Fulfill plots. Dimethoate and endosulfan did not provide comparable control of GPA following each application, and contamination in the dimethoate treatment was variable at harvest (Table 3). The Provado and Admire treatments did not provide significant protection form FGA at harvest, but heads examined from the Admire treatments were free from GPA contamination. Overall, the Assail and Flonicamid treatments provided the most consistent aphid control.

Table 1.

		Mean Green Peach Aphid / Plant								
Treatment	**Rate**	**12-Jan**	**20-Jan**	**27-Jan**	**3-Feb**	**10-Feb**	**18-Feb**	**26-Feb**	**3-Mar**	**11-Mar**
Assail 70WP	1.7 oz	11.4 a	3.4 a	1.7 c	2.5 bc	1.1 d	4.5 cd	2.0 c	3.0 b	0.6
Fulfill 50WG	2.75 oz	10.4 a	8.4 a	5.1 bc	6.7 abc	6.5 cd	14.1 c	20.2 bc	5.3 b	6.6 bc
Flonicamid 50 DF	2.3 oz	6.6 a	4.3 a	2.2 c	1.4 c	1.1 d	7.0 cd	8.6 bc	3.0 b	2.2 c
Provado 1.6F	3.75 oz	8.3 a	3.3 a	3.8 bc	1.7 c	1.9 d	7.6 cd	5.2 bc	6.7 b	4.6 bc
Dimethoate 4E	8 oz	5.6 a	13.0 a	15.3 a	12.8 a	15.6 ab	37.9 ab	34.9 b	58.9 a	16.3 b
Endosulfan 3E	32 oz	5.9 a	11.0 a	7.5 abc	7.6 ab	10.8 bc	32.0 b	16.2 bc	19.8 b	6.7 bc
Admire 2F	16 oz	0.1 b	0.1 b	0.6 c	0.5 c	0.3 d	1.1 d	1.1 c	1.3 b	0.5 c
Admire 2F	20 oz	0.2 b	0.4 b	0.8 c	0.1 c	0.9 d	1.5 d	0.9 c	1.2 b	1.6 c
Untreated		8.0 a	4.4 a	11.9 ab	15.5 a	24.0 a	48.2 a	75.2 a	86.8 a	97.9 a

Means followed by the same letter are not significantly different, ANOVA; protected LSD $_{(p>0.05)}$

Table 2.

Treatment	Rate	Mean Foxglove Aphid / Plant								
		12-Jan	**20-Jan**	**27-Jan**	**3-Feb**	**10-Feb**	**18-Feb**	**26-Feb**	**3-Mar**	**11-Mar**
Assail 70WP	1.7 oz	0.0 a	0.0 a	0.1 a	0.1 a	0.3 a	0.1 b	0.6 b	0.1 b	0.5 b
Fulfill 50WG	2.75 oz	0.0 a	0.0 a	0.1 a	0.1 a	0.0 a	0.5 b	0.7 b	0.2 b	0.0 b
Flonicamid 50 DF	2.3 oz	0.0 a	0.0 a	0.1 a	0.0 a	0.0 a	0.2 b	0.0 b	0.2 b	0.0 b
Provado 1.6F	3.75 oz	0.0 a	0.0 a	0.0	0.1 a	0.0 a	0.0 b	1.6 b	3.0 b	11.4 b
Dimethoate 4E	8 oz	0.0 a	0.0 a	0.2 a	0.0 a	0.0 a	0.0 b	0.5 b	1.0 b	1.1 b
Endosulfan 3E	32 oz	0.0 a	0.0 a	0.1 a	0.0 a	0.2 a	0.3 b	0.7 b	0.3 b	0.0 b
Admire 2F	16 oz	0.0 a	0.0 a	0.4 a	0.5 a	0.0 a	6.8 ab	0.2 b	6.6 b	11.9 b
Admire 2F	20 oz	0.0 a	0.0 a	0.1 a	0.3 a	0.0 a	1.3 b	1.4 b	8.3 b	8.0 b
Untreated		0.0 a	0.4 a	0.3 a	0.1 a	0.3 a	15.7 a	52.4 a	47.9 a	77.1 a

Means followed by the same letter are not significantly different, ANOVA; protected LSD *(p>0.05)*

Table 3.

Treatment	Rate/ac	Avg. No. Aphids / Head			% Contaminated Heads (> 5 aphids)		
		GPA	FG	Total	GPA	FG	Total
Assail	1.7 oz	0.2 b	0.2 b	0.4 b	0.0 c	0.0 d	0.0 d
Fulfill	2.75 oz	2.0 b	0.0 b	1.9 b	14.8 b	0.0 d	9.5 cd
Flonicamid	2.3 oz	0.7 b	0.0 b	0.7 b	0.0 c	0.0 d	0.0 d
Provado	3.75 oz	1.4 b	4.0 b	5.4 b	9.5 b	29.5 b	33.3 b
Dimethoate	8 oz	2.2 b	0.5 b	2.7 b	14.8 b	4.8 cd	19.1 bcd
Endosulfan	32 oz	1.7 b	0.1 b	1.7 b	4.8 bc	0.0 d	4.8 cd
Admire	16 oz	0.1 b	7.1 b	7.2 b	0.0 c	24.1 b	28.6 bc
Admire	20 oz	0.3 b	3.0 b	3.3 b	0.0 c	28.9 b	28.6 bc
Untreated		23.0 a	34.1 a	57.1 a	80.2 a	52.4 a	100 a

Means followed by the same letter are not significantly different, ANOVA; protected LSD $_{(p>0.05)}$

Seasonal Abundance of Thrips Populations in Head Lettuce

Materials and Methods

Studies to examine the spatial and temporal abundance of thrips populations were conducted on head lettuce at the Yuma Agricultural Center, Yuma, Arizona. Beginning in mid-September, 0.25 acre plots of head lettuce were planted at 2-2 week intervals. On each planting date (PD) lettuce was direct seeded into double row beds on 42 inch centers. Each planting was subdivided into 5 untreated plots and each plot consisted of 4 beds, 80 feet long. No insecticide applications were made during the study.

Thrips populations were assessed by estimating the number of thrips adults and larvae / plant by taking relative beat pan samples 4-5 times throughout each planting beginning at thinning and ending at harvest. On each sample date, four whole plants (n=20 per sampling date) were selected at random in each plot and individually removed from the soil at ground level. Plants were then beat vigorously against a screened pan for a predetermined duration (5-10 hits for upper and lower plant portion). The pan measured 2" H by 15" L by 8" W and covered with meshed screen with 0.5 spacing. Inside of the pan was a yellow sticky trap (6" by 6") to catch and retain dislodged thrips. On samples collected at harvest, counts of heads and frame leaves were conducted separately. Head samples consisted of the head, with cap leaf and 2 wrapper leaves. The head was then split in two and beat against the screen also. Frame leaf samples consisted of removing the head and 2 wrapper leaves and exposing as many leaves as possible while then beating the plant vigorously. Sticky traps were immediately covered with clear plastic and then taken to the laboratory where adult and larvae were counted under 10-20X magnification. Weather data was summarized for each sample date. Ambient temperatures for each AZMET site was prepared and provided graphically showing relative weekly trends across the season.

Results and Discussion

Seasonal population abundance of adult, larvae and total thrips during six lettuce planting dates over a three year period from 2001 to 2004 is shown in Figures 1-3. These data show that thrips reproduction and development on lettuce is largely influenced by temperature. This can be seen for each life stage within each planting where population abundance was greatest during the later lettuce plantings during Nov and Dec where temperatures averaged 60-65 degrees F. Population development was at its lowest level in the October plantings, particularly during the cooler winter periods. Although temperatures were quite warm during the March of 2004, thrips abundance was light, a consequence of unusually cool temperatures in January and early February. In contrast, greater development and abundance of thrips during the winter and spring in 2003, compared with 2002 and 2004, can largely be attributed to warmer temperatures in Dec, Jan and Feb.

This data suggests that during cool winters, October lettuce planting are at a lower risk of thrips infestation. However, this was not the case in 2003 due to mild winter conditions where all lettuce planting experienced significant thrips development and abundance. Table 1 shows the data for each year averaged across planting dates. This summary clearly shows the large abundance of thrips that occurred in 2003-2003 season, and strongly supports our contention that growers should be most cautious of thrips infestations in lettuce planted during November and December. Finally, this data demonstrates that western flower thrips are capable of reproducing and developing large population densities on head lettuce under winter and spring growing conditions in the desert.

Table 1. Western flower thrips per plant averaged across lettuce plantings and years, Yuma Agricultural Center

Adults

Season	Wet date 17-Sep	10-Oct	30-Oct	15-Nov	2-Dec	15-Dec	**4 Yr Avg**
2001-2002	16.1	9.2	7.4	8.6	15.1	16.9	12.2
2002-2003	20.1	14.4	19.2	43.8	32.3	39.2	**28.2**
2003-2004	7.1	7.5	9.8	9.3	8.9	13.1	9.3
2004-2005	8.9	4.9	5.0	8.0	9.4	15.4	8.6
4 Yr Avg	13.1	9.0	10.4	17.4	16.4	**21.2**	

Larvae

Season	Wet date 17-Sep	10-Oct	30-Oct	15-Nov	2-Dec	15-Dec	**4 Yr Avg**
2001-2002	27.2	14.4	9.5	14.4	20.8	49.0	22.6
2002-2003	21.7	31.3	46.9	67.2	45.3	26.8	**39.9**
2003-2004	7.1	18.5	16.1	13.3	10.6	23.9	14.9
2004-2005	10.3	7.5	6.0	4.2	4.4	13.0	7.6
4 Yr Avg	16.6	17.9	19.6	24.8	20.3	**28.2**	

Total Thrips

Season	Wet date 17-Sep	10-Oct	30-Oct	15-Nov	2-Dec	15-Dec	**4 Yr Avg**
2001-2002	43.3	23.6	16.9	23.0	35.9	65.9	34.8
2002-2003	41.7	45.7	66.2	111.8	68.5	66.0	**66.7**
2003-2004	14.1	26.0	25.9	22.6	19.5	45.0	25.5
2004-2005	19.2	12.4	11.1	12.2	13.8	26.4	15.9
4 Yr Avg	29.6	26.9	30.0	42.4	34.4	**50.8**	

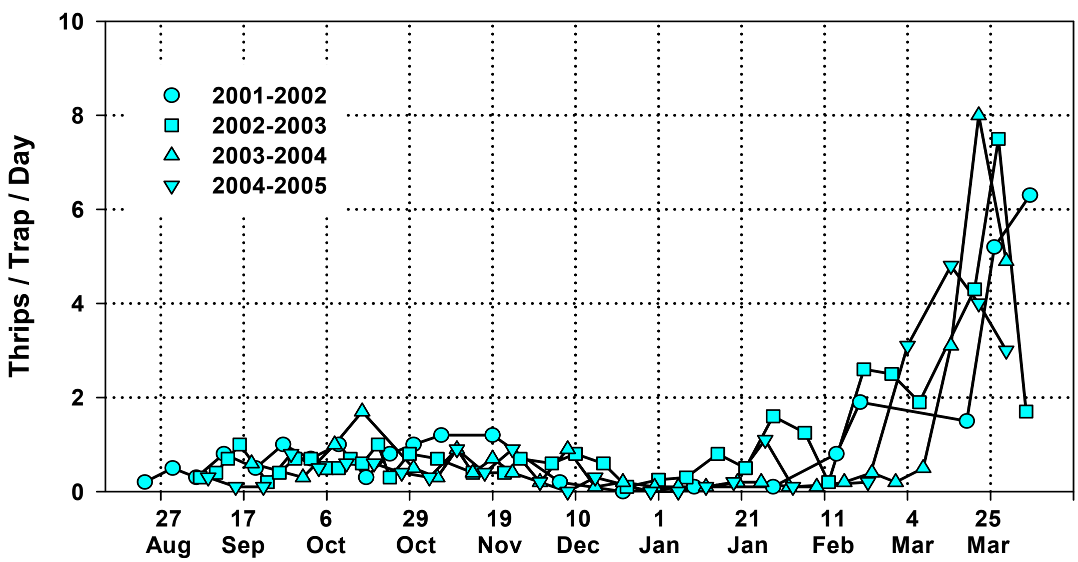

Figure 1. Seasonal flight activity of western flower thrips adults the Yuma Valley across several years, 2001-2005.

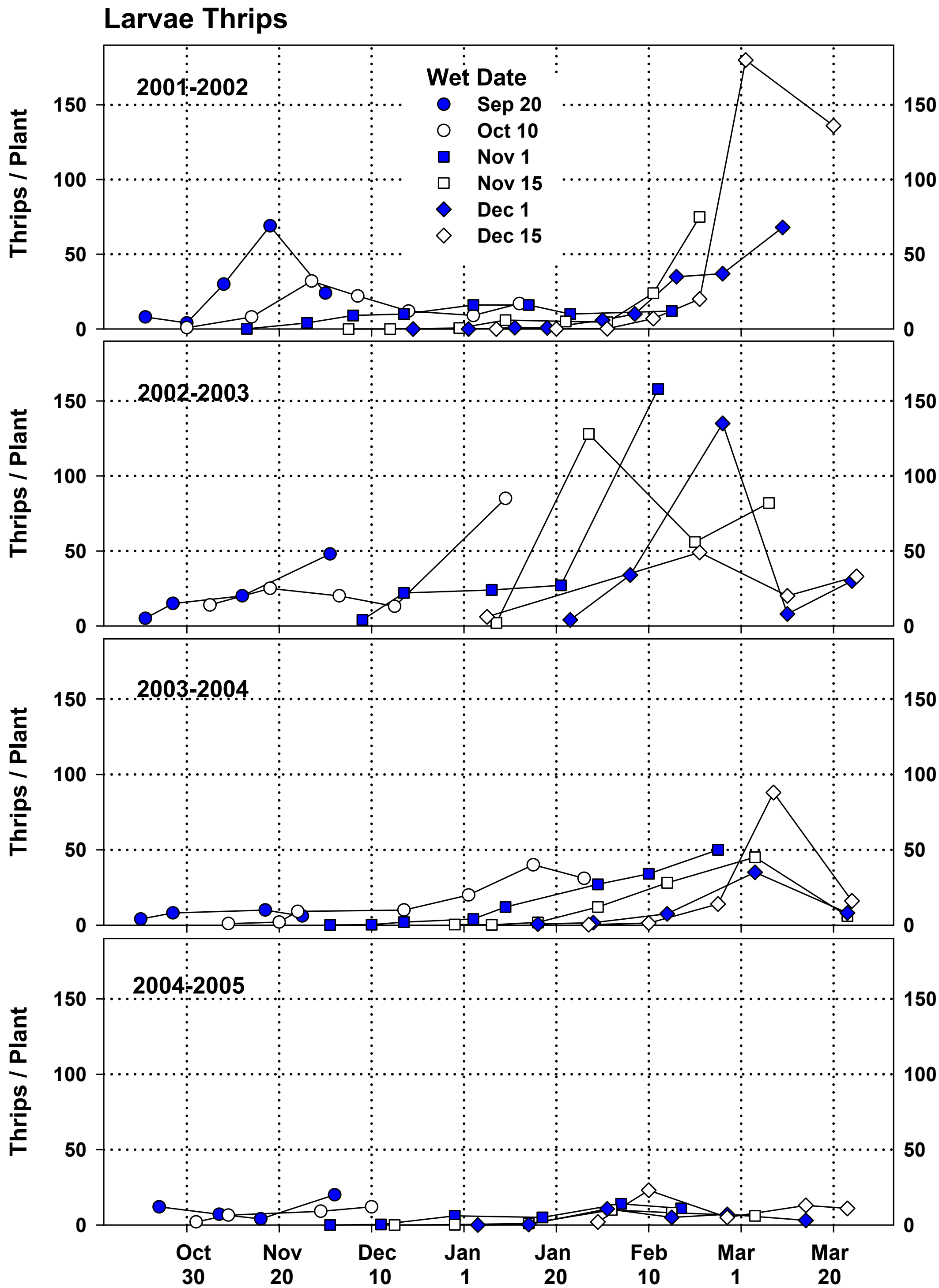

Figure 2. Seasonal Abundance of Western Flower Thrips larvae in Several Plantings of Head Lettuce , Yuma Agricultural Center, 2001-2005

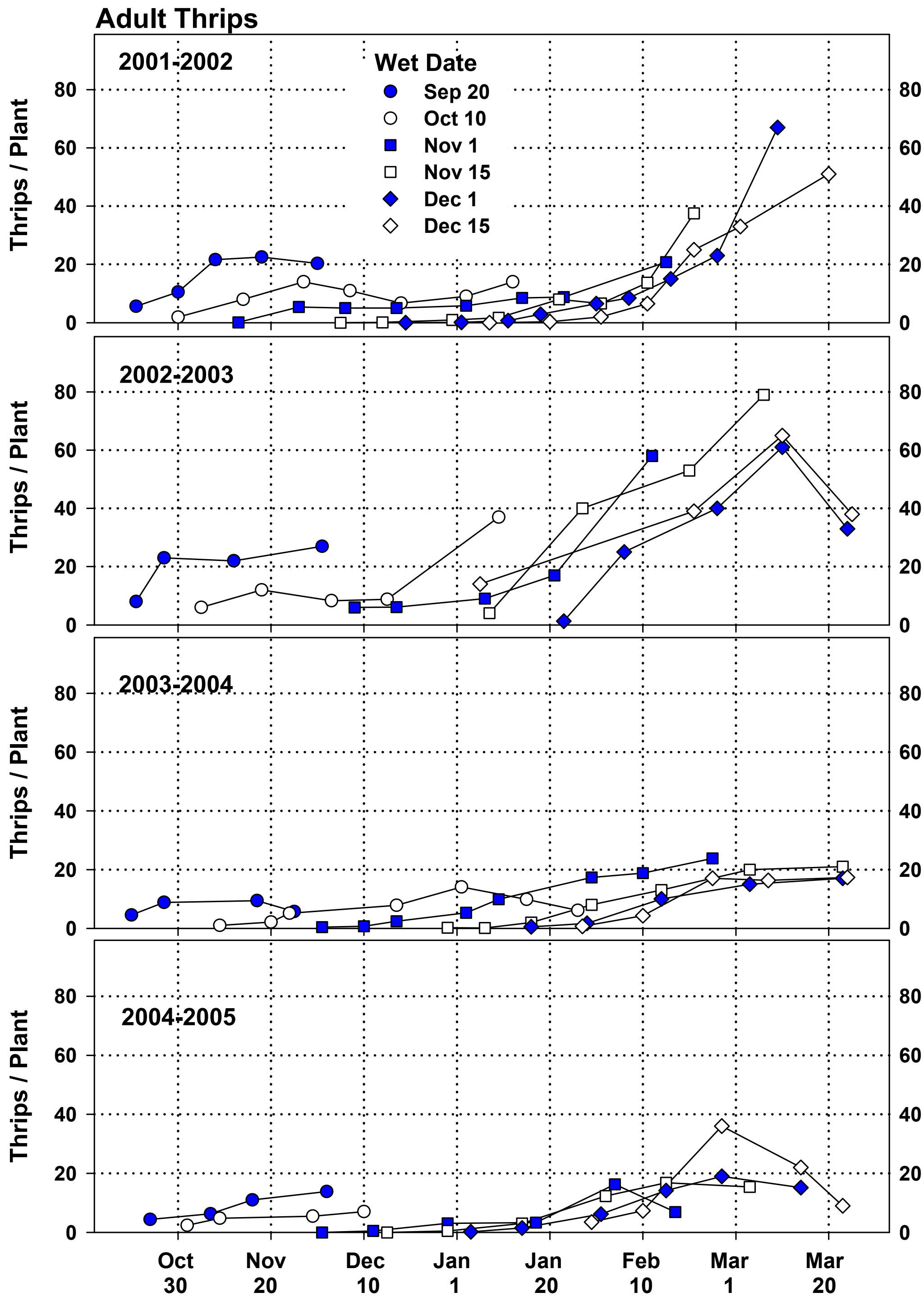

Figure 3. Seasonal Abundance of Western Flower Thrips adults in Several Plantings of Head Lettuce , Yuma Agricultural Center, 2001-2005

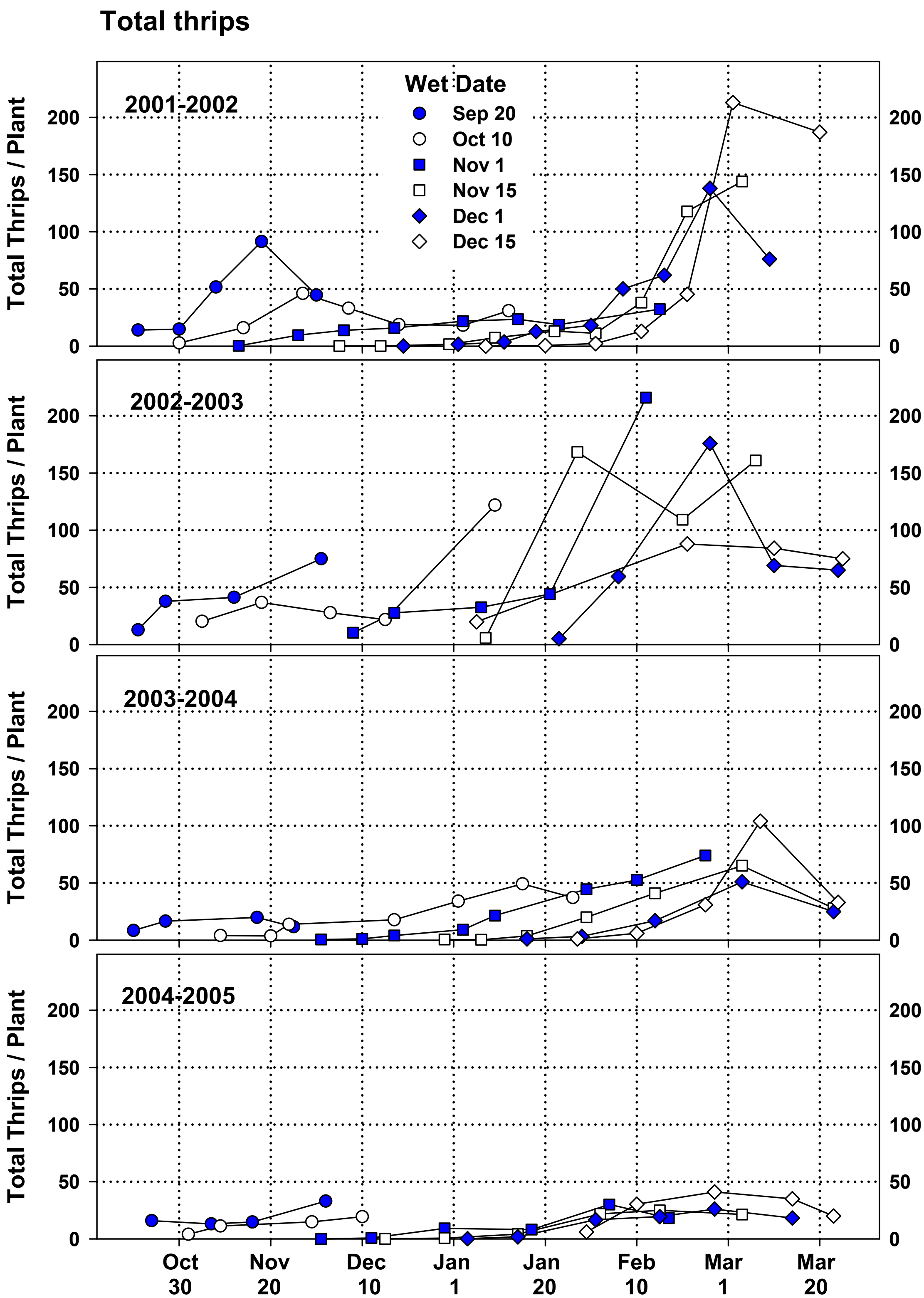

Figure 4. Seasonal Abundance of Total Western Flower Thrips (Adults and Larvae) in Several Plantings of Head Lettuce, Yuma Agricultural Center, 2001-2005.

Insecticide Efficacy Against Western Flower Thrips in Lettuce

Study 1.

Materials and Methods

The objective of the study was to compare the efficacy of the new insecticide Tesoro (pyridalyl) with other standard combinations for control of western flower thrips on head lettuce under desert growing conditions. Lettuce was direct seeded on 17 Nov, 2004 at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 4 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a randomized complete block design. Formulations and rates for each compound are provided in the tables. Foliar sprays were applied on 15 Jan, 27 Jan, and 5 Feb with a CO_2 operated boom sprayer at 60 psi and 21.5 gpa. A broadcast application was delivered through 2 TX-18 ConeJet nozzles per bed. An adjuvant, DyneAmic (Helena Chemical Co.), was applied at 0.125% v/v to all treatments. Numbers of WFT from 5 plants per replicate were recorded on each sample date. Relative WFT numbers were measured by removing plants and beating them vigorously against a screened pan (12 in. x 7 in. x 2 in) for a predetermined time (15 sec). A 6 in. by 6 in. sticky trap was placed inside of the pan to catch the dislodged WFT. Sticky traps were then taken to the laboratory where adult and larvae were counted. Data were analyzed as a 1-way ANOVA with means compared where appropriate using a protected LSD *F* test $_{(p<0.05)}$.

Results and Discussion

WFT populations were light to moderate during the trial. Following the 1st application, none of the spray treatments significantly reduced adult WFT compared to the untreated control at 2 DAT (Table 1). However, by 6 and 9 DAT, all the treatments significantly reduced adult WFT numbers with the exception of the Dimethoate + Provado treatment. Following the 2nd and 3rd applications, all treatments had significantly reduced WFT adults. The Tesoro treatments provided adult WFT control similar to the industry standard (Lannate + Mustang Max). Among the treatment combinations, the addition of Exponent (PBO) as a synergist to the Lannate+Mustang Max treatment did not significantly improve control. WFT larvae numbers following the 1st application did not differ among the spray treatments and the untreated control (Table 2). At 4-DAT #2, all treatments except the Tesoro (6.5 oz) and Dimethoate +Provado, significantly reduced WFT larvae numbers compared to the untreated. However, by 9 DAT #2 and following the 3rd application, all treatments had significantly fewer WFT larvae than the untreated. Similar to what we observed with the adult WFT, the addition of the synergist to Lannate +Mustang Max treatment did not significantly improve control. Overall, Tesoro appeared to be a have adulticide activity against WFT comparable to the industry standards, but was less active on larvae, particularly at the lower rate. Dimethoate+Provado, which is a common treatment for aphids on desert lettuce, was inconsistent against WFT. No phytotoxicty was observed.

Table 1.

		Mean Adults / Plant						
		Application # 1			Application # 2		Application # 3	
		2 DAT	**6 DAT**	**9 DAT**	**4 DAT**	**9 DAT**	**4 DAT**	**9 DAT**
Treatment	**Rate**	**17-Jan**	**21-Jan**	**24-Jan**	**31-Jan**	**5-Feb**	**9-Feb**	**14-Feb**
Tesoro 4EC	6.5 oz	1.7 a	2.5 b	2.7 bcd	1.8 d	1.7 c	1.4 cd	3.7 cd
Tesoro 4EC	13 oz	1.1 a	2.1 b	2.6 bcd	1.9 d	0.9 c	1.7 cd	3.2 cd
Lannate SP+Mustang Max	0.8 lb + 4 oz	0.4 a	1.3 b	1.5 cde	1.9 d	1.3 c	1.8 cd	1.9 d
Lannate+Mustang+Exponent[a]	0.8 lb+4+7 oz	0.6 a	1.5 b	1.3 de	1.6 d	1.6 c	1.2 d	2.1 d
Endosulfan 3EC+Mustang	40 oz + 4 oz	0.8 a	1.2 b	0.9 e	1.2 d	1.6 c	1.6 cd	4.0 cd
Dimethoate E267 +Mustang	12 oz + 4 oz	0.6 a	1.5 b	1.4 cde	1.0 d	1.1 c	2.0 bcd	3.2 cd
Endosulfan +Provado 1.6F	40 oz + 3.75 oz	1.0 a	3.9 a	2.9 bc	3.3 c	3.6 b	3.8 bc	7.7 b
Dimethoate+Provado	12 oz +3.75 oz	2.0 a	4.1 a	4.1 ab	5.2 b	4.3 b	4.4 b	5.6 bc
Endosulfan+Dimethoate+Mustang	40 oz +12 oz+ 4 oz	0.9 a	1.4 b	1.5 cde	1.1 d	0.5 c	0.9 d	2.3 d
Untreated		1.6 a	5.0 a	5.7 a	6.7 a	6.8 a	9.1 a	11.2 a

[a] piperonyl butoxide, technical , 91.3 %

Means followed by the same letter are not significantly different, ANOVA; protected LSD $_{(p>0.05)}$

Table 2.

		Mean Larvae / Plant						
		Application # 1			Application # 2		Application # 3	
		2 DAT	6 DAT	9 DAT	4 DAT	9 DAT	4 DAT	9 DAT
Treatment	**Rate**	**17-Jan**	**21-Jan**	**24-Jan**	**31-Jan**	**5-Feb**	**9-Feb**	**14-Feb**
Tesoro 4EC	6.5 oz	1.1 a	4.0 a	4.1 a	5.7 a	2.2 c	2.7 cd	1.6 bc
Tesoro 4EC	13 oz	1.0 a	3.0 a	3.5 a	2.6 b	1.3 c	2.3 de	0.8 bc
Lannate SP+Mustang Max	0.8 lb + 4 oz	0.4 a	1.5 a	1.7 a	1.9 b	0.8 c	1.3 de	0.7 c
Lannate+Mustang+Exponent[a]	0.8 lb+4+7 oz	0.2 a	0.6 a	1.9 a	0.8 b	0.6 c	0.6 e	0.6 c
Endosulfan 3EC+Mustang	40 oz + 4 oz	0.4 a	1.2 a	5.1 a	1.6 b	1.5 c	1.8 de	1.0 bc
Dimethoate E267 +Mustang	12 oz + 4 oz	0.2 a	1.9 a	3.4 a	2.1 b	1.7 c	1.7 de	0.9 bc
Endosulfan +Provado 1.6F	40 oz + 3.75 oz	1.1 a	3.2 a	2.1 a	1.8 b	2.4 c	4.3 bc	1.4 bc
Dimethoate+Provado	12 oz +3.75 oz	1.4 a	2.4 a	4.5 a	5.6 a	4.9 b	4.7 b	2.8 b
Endosulfan+Dimethoate+Mustang	40 oz+12 oz+ 4 oz	0.9 a	1.6 a	2.5 a	1.8 b	0.7 c	0.8 e	0.6 c
Untreated	--	1.1 a	2.7 a	4.5 a	6.9 a	8.8 a	13.4 a	8.3 a

[a] piperonyl butoxide, technical , 91.3 %

Means followed by the same letter are not significantly different, ANOVA; protected LSD $_{(p>0.05)}$

Study 2.

Materials and Methods

The objective of the study was to compare the efficacy of the new insecticide Tesoro (pyridalyl) with industry standards for control of western flower thrips on romaine lettuce under desert growing conditions. Lettuce was direct seeded on 20 Sep at the Yuma Valley Agricultural Center, Yuma, AZ into double row beds on 42 inch centers. Stand establishment was achieved using overhead sprinkler irrigation, and irrigated with furrow irrigation thereafter. Plots were two beds wide by 35 ft long and bordered by two untreated beds. Four replications of each treatment were arranged in a randomized complete block design. Formulations and rates for each compound are provided in the tables. Foliar sprays were applied on 31 Oct, 8 Nov and 17 Nov with a CO_2 operated boom sprayer at 60 psi and 21.5 gpa. A broadcast application was delivered through 2 TX-18 ConeJet nozzles per bed. An adjuvant, DyneAmic (Helena Chemical Co.), was applied at 0.06 - 0.125% to all treatments. Numbers of WFT from 5 plants per replicate were recorded on each sample date. Relative WFT numbers were measured by removing plants and beating them vigorously against a screened pan (12 in. x 7 in. x 2 in) for a predetermined time (15 sec). A 6 in. by 6 in. sticky trap was placed inside of the pan to catch the dislodged WFT. Sticky traps were then taken to the laboratory where adult and larvae were counted. Data were analyzed as a 1-way ANOVA with means compared where appropriate using a protected LSD *F* test $_{(p<0.05)}$.

Results and Discussion

WFT populations were moderate during this fall trial. All treatments significantly reduced adult WFT following the 1st and 2nd applications with the exception of Success (Table 1). This was not surprising as previous trials have shown that Success at 6 oz provides inconsistent adult efficacy. Sprays of Tesoro significantly reduced adult WFT following each application, statistically comparable to the standard Lannate+Mustang Max. In contrast, all treatments significantly reduced WFT larvae numbers following each application (Table 2). Success and Orthene provided the most consistent suppression of WFT larvae. The combination of Tesoro and Orthene provided significantly better knockdown of WFT larvae following the 1st and 2nd applications (4-DAT) compared with the Tesoro applied alone. However, Tesoro applied alone provided similar residual control to the combination treatment at 7-8 DAT. Overall, Tesoro appears to have adult WFT activity comparable to the industry standards, but may be somewhat weaker in larval control, particularly in terms of knockdown activity. No phytotoxicty was observed.

Table 1.

Treatment	Rate/ac	Mean Adults / Plant					
		27-Oct	3-Nov	7-Nov	11-Nov	16-Nov	23-Nov
Lannate SP+Mustang Max	0.5 lb+ 4oz	9.7 a	2.6 b	3.8 b	2.2 cd	3.8 bc	1.5 b
Success 2F	6 oz	9.9 a	5.1 a	4.3 b	4.8 b	7.0 b	4.3 b
Orthene 97	0.75 lb	7.8 a	1.3 c	4.4 b	1.9 d	2.7 c	1.9 b
Tesoro 4EC +Orthene 97	6 oz+0.75 lb	10.1 a	1.3 c	2.4 b	2.7 cd	2.0 c	1.9 b
Tesoro 4EC	6 oz	9.6 a	2.9 b	4.0 b	4.0 bc	5.4 bc	4.6 b
Untreated	--	7.0 a	6.2 a	7.0 a	10.7 a	11.3 a	9.3 a

Means followed by the same letter are not significantly different, ANOVA; protected LSD *($p>0.05$)*

Table 2.

Treatment	Rate/ac	Mean Larvae / Plant					
		27-Oct	3-Nov	7-Nov	11-Nov	16-Nov	23-Nov
Lannate SP+Mustang Max	0.5 lb+ 4oz	82.4 a	26.4 bc	16.0 bc	4.1 cd	0.7 c	0.9 b
Success 2F	6 oz	75.7 a	25.2 bcd	12.8 c	3.6 d	2.8 b	1.7 b
Orthene 97	0.75 lb	76.2 a	12.7 d	18.9 bc	7.4 bc	1.5 bc	1.1 b
Tesoro 4EC +Orthene 97	6 oz+0.75 lb	79.5 a	16.6 cd	19.3 bc	5.4 cd	1.8 bc	1.1 b
Tesoro 4EC	6 oz	81.6 a	35.0 ab	24.8 b	9.6 b	2.3 b	1.9 b
Untreated	--	87.9 a	46.3 a	37.9 a	18.1 a	11.2 a	10.0 a

Means followed by the same letter are not significantly different, ANOVA; protected LSD *($p>0.05$)*